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(54) **Arrangement for actuating a motor vehicle friction clutch disconnects engine accelerator control until after gearshift**

(57) For the automatic actuation of a friction clutch (5) arranged between an engine (1) and a gearbox (7) of a motor vehicle there is proposed a control means (19) which reduces the power of the engine (1) during the gear change of the gearbox (7) while the gearbox is shifted via the neutral gear position thereof. During re-clutching after the gear change, the engine speed is automatically adapted to the gearbox input speed in order to avoid a clutching jolt. "Double-declutching" is carried out when shifting down the gearbox (7) to minimise the load on controlled synchroniser mechanisms of the gearbox (7).

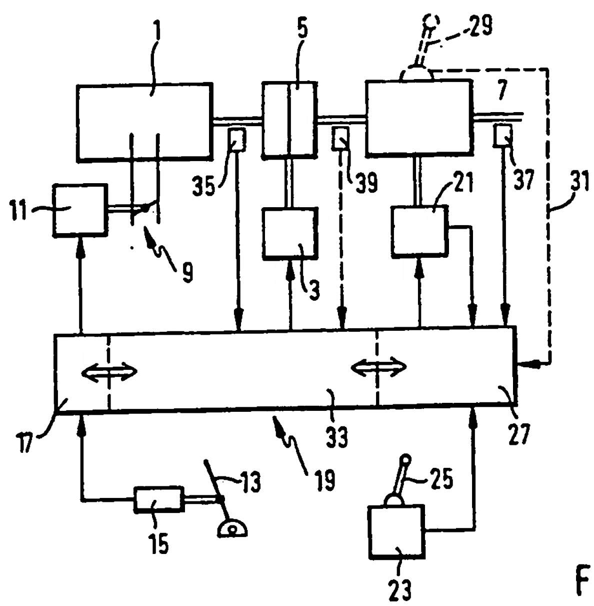

FIG.1

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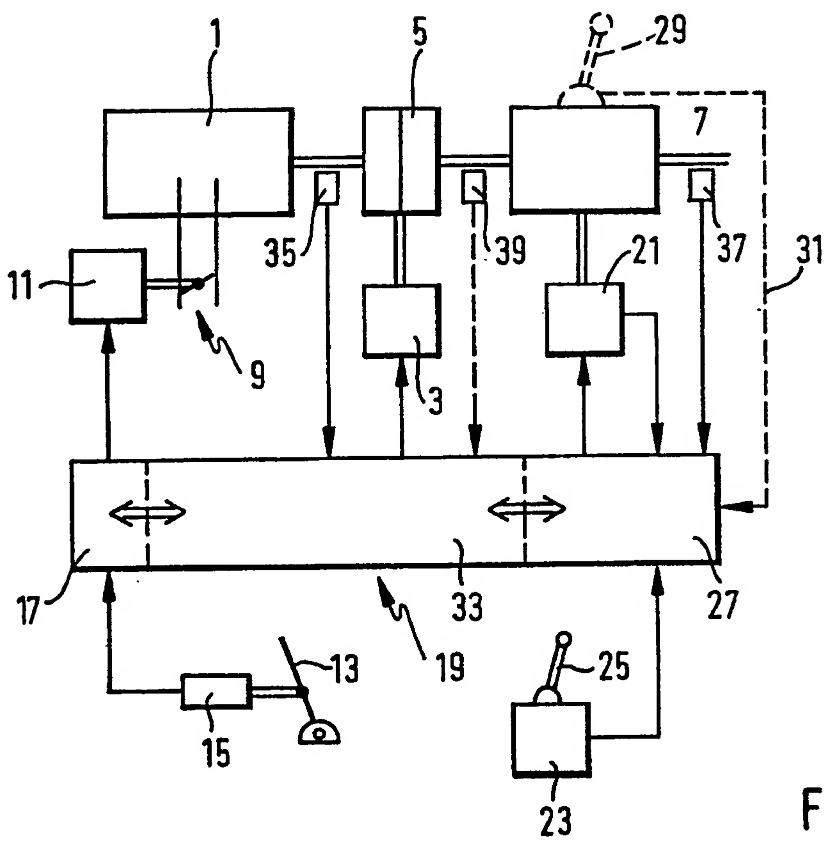
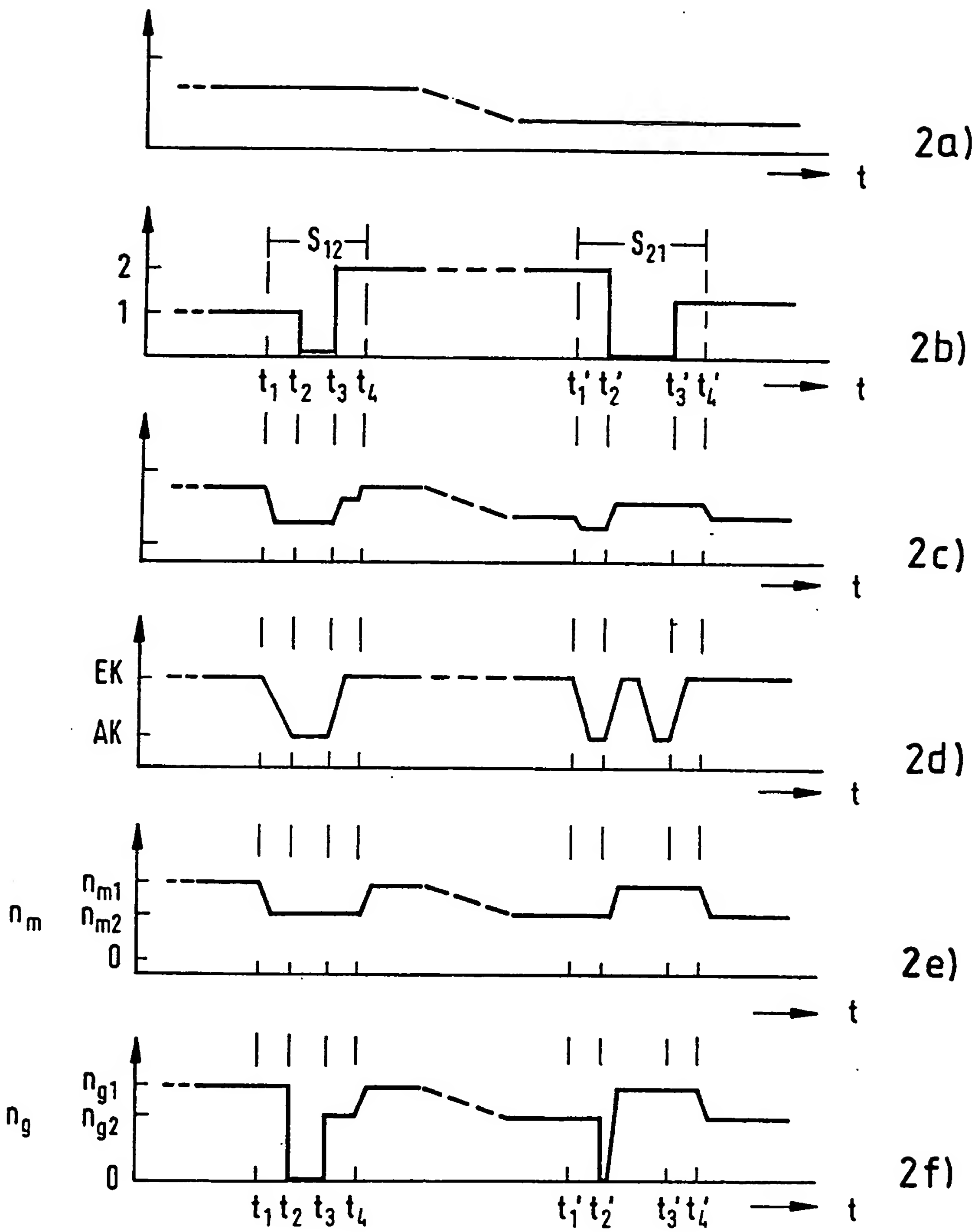


FIG.1

FIG. 2



2a)
t
S12
S21
2
1
t1 t2 t3 t4
t1' t2' t3' t4'
2b)
2c)
EK
AK
2d)
nm1
nm
nm2
0
2e)
ng1
ng
ng2
2f)

ARRANGEMENT FOR ACTUATING A MOTOR VEHICLE FRICTION CLUTCH

The invention relates to an arrangement for actuating a friction clutch arranged between an engine and a gearbox of a motor vehicle.

An arrangement for the automatic actuation of a motor vehicle friction clutch is known from DE-A-30 04 930, in which the clutch is disengaged and engaged by a clutch actuator both during start-up and during a gear change. An intended gear-shift recognition system in the form of a gear-shift lever contact or the like triggers the declutching process, whereupon the formerly adjusted gear position of the gearbox is shifted into the new gear position via a neutral gear position. In the new gear position, the clutch is then engaged, for example at a predetermined setting speed. To avoid a fairly great clutching jolt, depending on the driving situation, the engine speed and the gearbox input speed are detected using speed sensors and a control means adapts the engine speed prior to clutching to the gearbox input speed. The power setting system of the engine, for example its throttle valve or injection pump, is adjusted by a power actuator until the engine speed satisfies the aforementioned condition. After speed adaptation, the clutch can be engaged without a clutching jolt.

In the arrangement known from DE-A-30 04 930, the driver has to assist the coupling process by a suitable actuation of the accelerator pedal. Depending on the driving situation, this demands some practice if losses of comfort are to be avoided. For example, if the driver actuates the gear-shift lever while still depressing the accelerator pedal, the engine accelerates unintentionally during the gear change in the neutral gear position. On the other hand, if the driver actuates the accelerator pedal too early during meshing of the next gear, i.e. before the new gear meshes

completely, the resultant increased engine speed has to be absorbed by slippage of the clutch. This increases clutch wear. On the other hand, if the driver allows too much time to elapse after meshing of the gear, before he actuates the accelerator pedal again, he loses acceleration.

A further arrangement for the automatic actuation of a friction clutch in conjunction with an automatic gearbox of a motor vehicle is known from US Patent 4 281 751, in which the throttle valve is initially at least partially closed by means of a throttle valve drive for the gear change before the clutch is disengaged for the gear change. After the gear change, the clutch is engaged and the throttle valve is also opened again after some delay. With this arrangement, the throttle valve is controlled *via* a mechanical linkage from the accelerator pedal, and the throttle valve actuator merely allows closure thereof for the gear-changing process.

An object of the invention is to improve the arrangement of the generic type such that, while substantially sparing the friction clutch and without losses of comfort, the gear speeds of the gearbox can be changed.

According to the invention there is provided an arrangement for actuating a friction clutch arranged between an engine and a gearbox which engages and disengages the clutch, an engine speed sensor which detects the engine speed, a device determining the gearbox input speed, a pedal position sensor detecting the position of an accelerator pedal, a power actuator which actuates a power setting system

of the engine as a function of the pedal position sensor, an intended gear-shift recognition system which detects the initiation of a gear change of the gearbox during which there is a changeover from a gear position already adjusted earlier on *via* a neutral gear position into a new gear position and a control means which responds to the engine speed sensor, the gearbox speed determining device, the pedal position sensor and the intended gear-shift recognition system, controls both the clutch actuator and the power actuator, disengages and engages the clutch by means of the clutch actuator for the gear change and controls the power setting system during engagement so that the engine speed is substantially equal to the gearbox input speed, characterised in that the control means controls the power actuator during the gear change independently of the position of the accelerator pedal detected by the pedal position sensor and sets it back into the position determined by the accelerator pedal immediately after engagement of the clutch.

In the context of the invention, the control means controls not only the clutch actuator but also a power actuator of the engine during the gear change. The control means controls the engine speed during the gear change, which can take place either manually or, in the case of an automatic transmission, automatically, independently of the instantaneous adjustment of the accelerator pedal which in turn controls the power setting system by means of the power actuator during travel, i e before and after the gear change. During the gear change, i e before the new gear

position is completely adjusted on the gearbox, the control means sets the engine speed by means of the power setting system to the value of the gearbox input speed obtained in the new gear position owing to the speed of travel. Then or optionally also while overlapping in time, the control means engages the clutch via its actuator. A clutching jolt is avoided by adapting the engine speed to the gearbox input speed. Immediately after complete engagement of the clutch, i.e. without an additional time delay and optionally even somewhat in advance in time, the control system controls the power actuator back into the position determined by the accelerator pedal. Although the driver is not able to influence the engine speed via the accelerator pedal during the automatic coupling process, the control means can be set to an optimum traction interruption during the gear change on the one hand and the resultant clutch friction work on the other hand. As the speed control passes without a time delay to the accelerator pedal after the gear change, "sluggish" engine behaviour is avoided.

To enable the engine speed to be adapted to the gearbox input speed obtained at the gearbox input shaft when the new gear meshes according to the speed of travel, the gearbox input speed must be known. With the arrangement known from DE-A-30 04 930, the gearbox input speed is measured by means of a speed sensor. However, the information about the measured speed is available only after the new gear has meshed completely. In practice, this leads to a delay in the clutching process and therefore to losses of comfort during the gear change. In a preferred design, it is therefore proposed that the intended gear-shift recognition system produces an intended gear-shift signal representing the new gear position, before the gearbox is completely set to the new gear position, and that the control means calculates the gearbox input speed resulting in the new gear position as a function of the intended gear-shift

signal, more specifically also before the gearbox is adjusted to the new gear speed. The control means then adjusts the power setting device such that the engine speed is substantially equal to the calculated gearbox input speed. In this way, the time period required for adapting the engine speed to the gearbox input speed can be advanced and the time interval required for the gear change can be shortened.

The intended gear-shift signal representing the new gear before meshing thereof is available anyway in an automatic transmission. However, it can also be derived in a manually shifted gearbox from the direction in which the manually operated gear-shift lever is guided over the neutral gear position. Sensors can be provided to monitor the movement, guided in a gear-shift gate, of the gear-shift lever or of a part of the gearbox connected thereto.

When shifting a gearbox having controlled synchronisation down from a higher gear speed into a lower gear speed, comparatively great shifting forces have to be applied, particularly in the case of higher output gearbox speeds and this, on the one hand, necessitates relatively long shift times with a manually shifted gearbox and leads to high shift drive powers with an automatic gearbox. The shift resistance of the gearbox, which is dependent on the speed, complicates the control of the automatic clutch and can lead to a jolt of the vehicle when shifting down. On the other hand, a controlled acceleration of the gear-shifting process stresses the synchroniser mechanisms of the gearbox. To avoid these disadvantages, it is proposed in a preferred embodiment of the invention that the intended gear-shift recognition system produces an intended gear-shift signal which displays the increase of the gearbox input speed prior to meshing of the new gear speed during a gear change which raises the gearbox input speed of the new gear with respect to the gearbox input speed of the former gear and that the

control means engages the clutch in the presence of the intended gear-shift signal displaying the increase in the gearbox input speed and while the gearbox is located in the neutral gear position during the gear change and then disengages it again for the changeover from the neutral gear position into the new gear. Owing to the "intermediate coupling", while the gearbox is located in the neutral gear position, the gearbox input speed is accelerated, while the clutch is engaged, to the speed expected after meshing of the new gear. The new gear can then mesh rapidly after declutching, without difficulty and without stressing the synchroniser mechanisms of the gearbox having controlled synchronisation.

An embodiment of the invention is described in more detail hereinafter with reference to drawings.

Figure 1 shows a block circuit diagram of an arrangement according to the invention for actuating a motor vehicle friction clutch.

Figure 2 shows timing diagrams to illustrate the mode of operation of the arrangement.

Figure 1 shows schematically an engine 1 of a motor vehicle which is connected, via a friction clutch 5 which can be positioned by an actuator 3 between a clutching position EK and a declutching position AK, to a transmission 7 which in turn acts upon the driving wheels of the motor vehicle. The engine 1 comprises a power adjusting device 9, for example a throttle valve or an injection pump, which can be controlled by a power actuator 11 independently of the position of an accelerator pedal 13 which is actuable by the driver of the motor vehicle. The accelerator pedal 13 is connected to a position sensor 15 which controls the power actuator 11 via a stage 17 of an electronic control means

designated generally by 19. In the embodiment illustrated, the gearbox 7 is an automatic transmission which can be shifted by an actuator 21 to one of several gear speeds with different step-down ratios, independently of the driving situation. A gear control stage 23 with a selector lever 25, which controls the actuator 21 via a stage 27 of the control means 19, is provided for selecting the gear speeds or groups of gear speeds. The actuator 21 (or the gearbox 7) also delivers gear-shift position signals which represent the instantaneous gear position of the gearbox 7 including its neutral gear position in which the gearbox input shaft is uncoupled from the gearbox output shaft. As indicated by a gear-shift lever 29 in Figure 1, the gearbox 7 can also be a manually shifted gearbox which supplies intended gear-shift signals designating the new gear to be meshing during a gear change to the stage 27 of the control means 19 before the new gear is meshed by means of the gear-shift lever 29. Intended gear-shift signals of this type can be derived, for example, from the direction in which the gear-shift lever 29 guided through a gear-shift gate or the like of the gearbox 7 leaves the neutral gear position again during a gear change.

The control means 19 also comprises a stage 33 which controls the actuator 3 of the clutch 5 and responds to the engine speed n_m detected by means of a speed sensor 35 and to the speed of travel of the motor vehicle detected by means of a speed sensor 37. The stage 33 controls the engagement and disengagement of the clutch 5 and can also respond to further travel parameters detected by the sensors which are not shown in greater detail, as known. In order to reduce clutch friction and to avoid clutching jolts during a gear change of the gearbox 7, the control means 19 controls not only the actuator 3 of the clutch 5 but also the actuator 11 of the power setting system 9. During the gear change, the guidance of the actuator 11 passes from the accelerator pedal 13 solely to the control means 19 which controls the actuator 11

in fixed temporal synchronisation with the actuator 3 of the clutch 5, more specifically depending on whether the gear change involves a shift up or down. In both types of gear change, the control means 19 calculates the gearbox input speed n_g, which results after meshing of the new gear at the input shaft of the gearbox 7 when the clutch is disengaged owing to the speed of travel of the vehicle, from the speed signals of the speed sensor 37 representing the speed of travel and the intended gear-shift signals, which designate the new gear to be engaged. The control means 19 adjusts the actuator 11 of the power adjusting system 9 such that the engine speed n_m is substantially equal to the calculated gearbox input speed n_g. After adaptation of the speeds, the clutch 5 can be engaged relatively rapidly via the actuator 3 without a clutching jolt. Immediately after the engagement of the clutch 5, the guidance of the actuator 11 passes back to the accelerator pedal 13, i.e. the power adjusting system 9 is set back to the position determined by the accelerator pedal 13 without a time delay. The engine 1 therefore very rapidly follows the current accelerator pedal command.

The mode of operation of the control means 19 is described in more detail hereinafter with reference to the timing diagrams shown in Figure 2.

Figure 2a shows, as a function of the time parameter t, the position of the accelerator pedal 13 which is detected by means of the sensor 15 and can vary between a rest position and a full-load position.

Figure 2b shows, as a function of the time t, examples of the gear position of the gearbox 7 which is shifted up, for example from the first gear into the second gear in period t_1 to t_4 and is shifted down from the second to the first gear in period t_1' to t_4'. Shifting up will be

considered first of all hereinafter. At moment t_1, the control stage 23 begins to produce an intended gear-shift signal S_{12} which represents the intention to change gear from the first to the second gear. The intended gear-shift signal can be triggered by contacting the gear-shift lever 29 in the case of a manually controlled gearbox. At the beginning of the intended gear-shift signal S_{12}, the control means 19 controls the actuator 3 of the clutch 5 from the clutching position EK into the declutching position AK. The power adjusting system 9 is simultaneously set, by means of the actuator 11, from the position determined by the accelerator pedal 13 into a position in which the engine speed n_m (Figure 2a) is approximately equal to the gearbox input speed n_g (Figure 2f) expected for the new gear position on the basis of the instantaneous speed of travel. Figure 2c shows the resultant time dependency of the fuel throughput which can vary between a full-load throughput and an idling throughput in the normal case. The clutch position determined by the actuator 3 is represented in Figure 2d. The engine speed n_m decreases from the speed value n_{m1} (Figure 2e) allocated to the accelerator pedal position (Figure 2a) at moment t_1 with the reduction of the fuel throughput and the declutching of the clutch 5. When the clutch is disengaged, the gearbox is shifted up beyond its neutral gear position, the gearbox input speed n_g decreasing from the value $n_{g1} = n_{m1}$ to zero, for example, (Figure 2f) in time period t_2 to t_3 in which the gearbox 5 is located in the neutral gear position, while the control means 19 increases the fuel supply via the actuator 11 of the power setting system 9 until the engine speed n_m has reached the value $n_{m2} = n_{g2}$, i.e. the gearbox input speed calculated for the fully meshed second gear speed. At moment t_3, the second gear speed is then meshed at the gearbox 5, the actual speed of the gearbox input shaft also rising to the value n_{g2}.

Overlapping the increase in engine speed, in time, the

actuator 3 of the clutch 5 is controlled in the engagement direction, more specifically such that the clutch 5 is engaged only when the speed condition $n_{m2} = n_{g2}$ is satisfied. The intended gear-shift signal S_{12} ends at moment t_4, indicating that the change of gear is terminated. The control means 19 subsequently releases the accelerator pedal 13 which has been ineffectively shifted during the gear change process, directly afterward, for controlling the actuator 11 so that the fuel throughput (Figure 2c) as well as the engine speed n_m (Figure 2e) and the gearbox input speed n_g (Figure 2f) change to values which are determined by the accelerator pedal position (Figure 2a).

During a shift down, for example from the second to the first gear speed, an intended gear-shift signal S_{21} is similarly produced, the intended gear-shift signal S_{21} beginning at moment t_1' and causing the control means 19 to control the actuator 3 into the declutching position AK of the clutch 5. At moment t_2', the gearbox 7 is shifted from the second gear into the neutral position. In the neutral gear position, the gearbox input speed n_g decreases. The engine speed n_m is increased from the value n_{m2} observed before the gear change to a value n_{m1} which is equal to the calculated value n_{g1} of the gearbox input speed after meshing of the first gear speed. As the value n_{g1} is greater than the value n_{g2} which the gearbox input shaft actually had prior to the gear change, "intermediate coupling" is automatically effected to release the synchroniser mechanism of the control-synchronised gearbox 7. For this purpose, the clutch 5 is engaged via the actuator 3 and is disengaged again shortly afterward (Figure 2b). The speed of the gearbox input shaft is therefore increased to a value which is expected after meshing of the first gear on the basis of the instantaneous speed of travel. At moment t_3', the first gear speed can then be meshed without stressing the synchroniser mechanism of the gearbox. As the engine speed

n_{m1} and the gearbox input speed n_{g1} are kept substantially equal during the intermediate coupling process, the clutch 5 can subsequently be rapidly engaged via its actuator 3 without a clutching jolt. At moment t_4', the intended gear-shift signal S_{21} signals the end of the gear change, and the control means 19 again releases the accelerator pedal 13 for the control of the actuator 11 of the power adjusting system 9. The fuel throughput (Figure 2c) and the engine speed n_m (Figure 2e) therefore changes to the value determined by the accelerator pedal 13.

With the arrangement described hereinbefore, the gearbox input speed to be calculated in advance during a gear change by the control means 19 is calculated as a function of the intended gear-shift signal and a signal representing the speed of travel, for example a signal representing the gearbox output speed. Alternatively, as shown in Figure 1, the gearbox input speed detected by means of a speed sensor 39 can also be utilised to calculate the gearbox input speed expected in the new gear. The fact that the speed of travel will not change or will only change insignificantly during the gear change is utilised so that the gearbox input speed adjusted in the old gear, multiplied by the gearbox ratio between old and new gear, is a measure of the gearbox input speed to be expected in the new gear. The control means 19 must store this speed value in some cases.

The arrangements described hereinbefore allow automatic coupling to be carried out conveniently while sparing the clutch 5 and the synchroniser mechanism of the gearbox 7.

CLAIMS:

1. Arrangement for actuating a friction clutch (5) arranged between an engine (1) and a gearbox (7) of a motor vehicle, comprising an actuator (3) which engages and disengages the clutch (5), an engine speed sensor (35) which detects the engine speed, a device (37; 39) determining the gearbox input speed, a pedal position sensor (15) detecting the position of an accelerator pedal (13), a power actuator (11) which actuates a power setting system (9) of the engine (1) as a function of the pedal position sensor (15), an intended gear-shift recognition system (23, 31) which detects the initiation of a gear change of the gearbox (7) during which there is a changeover from a gear position already adjusted earlier on via a neutral gear position into a new gear position, and a control means (19) which responds to the engine speed sensor (35), the gearbox speed determining device (37; 39), the pedal position sensor (15) and the intended gear-shift recognition system (23, 31), controls both the clutch actuator (3) and the power actuator (11), disengages and engages the clutch (5) by means of the clutch actuator (3) for the gear change and controls the power setting system (11) during engagement so that the engine speed is substantially equal to the gearbox input speed, characterised in that the control means (19) controls the power actuator (11) during the gear change independently of the position of the accelerator pedal (13) detected by the pedal position sensor (15) and sets it back into the position determined by the accelerator pedal (13) immediately after engagement of the clutch (5).

2. Arrangement according to claim 1, characterised in that the intended gear-shift recognition system (23, 31) produces an intended gear-shift signal representing the new gear position before the gearbox (7) is completely adjusted to the new gear position and in that the control means (19)

calculates the gearbox input speed produced in the new gear position as a function of the intended gear-shift signal before the gearbox (7) is adjusted to the new gear position and controls the power setting system (11) such that the engine speed is substantially equal to the calculated gearbox input speed.

3. Arrangement according to claim 1 or 2, characterised in that the intended gear-shift recognition system (23, 31) produces an intended gear-shift signal (S_{21}) displaying the increase of the gearbox input speed prior to meshing of the new gear during a gear change (change down) increasing the gearbox input speed of the new gear with respect to the gearbox input speed of the earlier gear and in that, in the presence of the intended gear-shift signal (S_{21}) displaying the increase of the gearbox input speed and while the gearbox (7) is located in the neutral gear position during the gear change, the control means (19) engages the clutch (5) and increases the engine speed and then disengages the clutch (5) again for the changeover from the neutral gear position into the new gear.

4. Arrangement according to one of claims 1 to 3, characterised in that the gearbox (7) has an actuator (21) which changes the gears and in that the intended gear-shift recognition system (23) is attached to a gearbox control means (27) controlling the actuator (21) of the gearbox (7).

5. Arrangement for actuating a friction clutch substantially as described by way of example with reference to Figure 1 of the accompanying drawings.